Formal Modelling & Verification of E-NIC Issuing System Via Colored Petri Nets (CPN)

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Abstract—National Identity Card (NIC) has a lot of importance to every country in the world. NIC issuing framework is a complex system and it is difficult to analyze the different components of the system and it's highly difficult to analyze the major objectives. It is accepted that giving national identity cards to all the residents would assist governments with combatting social perniciousness, for example, unlawful movement, fake exercises, just as empower the quickening of the social help conveyance component. This paper focuses on the removal of errors in a system, fast track issuing procedure of NIC for the benefit of citizens of the nation. Indeed, even with the technological environment, automation of (NIC) issuing system to improve proficiency and client-based methodology request consideration. To verify and validate such a system, formal methods are a well-researched area to model the dynamic behavior of the E-NIC issuing system. This paper endeavors to combine the Colored Petri-Nets (CPN) model with the CPN tool for evaluating the behavior of three (NIC) issuing scenarios. Coloured Petri nets enable empowers diverse modeling approaches that deliver a more affluent framework for such a complex formalism. Furthermore, CPN is visually more expressive as compared to simple elementary nets. State-Space analysis was likewise performed to ensure formal verification of the complex model by verifying the behavioral properties of the framework.

Keywords - NIC Issuing System, Colored Petri Nets (CPN), State Space Graph, National identity card system, Formal verification, Automation of NIC.

I. INTRODUCTION

Governments over the world are hurrying to develop a national identity framework. In the wake of the convergence worldwide relocation, terrorism threat, wrongdoing and misrepresentation, and the interest for modernization of open administrations, numerous legislatures around the globe are about consistent in their silver slug: identity strategy [1]. The essential work of a system is to connect a flood of information with an individual [2].

Giving National Identity or ID cards to the residents is a proportion of such distinguishing proof. Current administration requests that all people of a specific culture might be recognized in such a way in this way, that they are qualified to call themselves residents. Without recognizable proof, one can't play out the obligations of citizenship, for example, casting a ballot, nor appreciate the advantages, for example, insurance against outside or inside dangers to prosperity [3].

The presentation of National IDs has had any kind of effect on the lives of the residents over the nations, and it will keep on making a greater engraving on their lives in the future [4].

CPN is a suitable approach for system modelling due to its flexible nature of modelling discrete event dynamic system and to attain the concurrent nature of complex models during their execution [5]. CPN has a graphical representation and is very general, hence they can be used to describe a large variety of different systems. CPN can explicitly define both states and actions [6].

CPN can be used to define hierarchical descriptions of the systems [7]. However, a more expressive formal language is needed to model the internal behavior of such complex systems. Due to this CPN ML language is used to model the internal behavior of the E-NIC issuance system more expressively [8].

Tokens in CPN are in the form of colors which indicate specific data types. When all the input places that correspond to a particular transition having a valid colored token then that particular transition is enabled for firing. To yields, the essential colored tokens to is output places valid arc binding is used. Modification of data values of these colored tokens can be done through the firing of transitions in CPN [9].E-NIC

II. ISSUING SYSTEM

The project chosen here is the NIC procedure of the NADRA department. National Identity Card (NIC) is issued to the citizens of Pakistan. The unique 13-digit identification number is recognized all over the country. We have made a model of CNIC procedure in Pakistan. In our model, we have covered three scenarios.

- New ID Card
- Urgent ID Card
- Lost ID Card

In case of a new ID card, one needs to get an entry coupon. When his turn comes according to coupon number, his data is entered. The next step is to take photograph and fingerprint submissions. After this, he has to submit a fee and gets receipt of the fee and turn goes to the next person in the queue. To get an urgent ID card procedure is the same as new ID card but one has to submit the extra fee to receive ID card urgently. In this way, the number of the flow is increased as it divides into two scenarios i.e. make normal CNIC and make urgent CNIC. The third case is a lost ID card scenario. In this case, the person who has lost his ID card will make his complaint about the lost card. His complaint will be registered for further action. He has to submit a copy of the lost ID card. After then, he will submit the fee at the desk, get receipt and registration is completed. The turn goes to the next person and the process is gone on to serve others in the queue.

In this Petri-Net model, the above-mentioned scenarios have been made which show the entire workflow of this system. The Petri-Net model uses colored tokens to identify different objects. The flow of these tokens shows the entire functionality of the system.

III. FORMALIZATION OF E-NIC PROCESS MODEL

Formal modeling of the E-NIC Issuance System is formalizing in CPN. The working of the E-NIC issuance system model which is modeled through CPN starts with waiting for queue i.e. many people are at the NIC issuing office that is shown in place Queue of people. It has 5 tokens. 3 tokens for lost ID card and 2 for the new ID card. Input is available so transition named as define problem will be fired and token moves to the front desk. From this place, two transitions will be fired named as a complaint about lost CNIC and make new CNIC based on the value of variable p (discussed later in the document) as shown in Figure 1. At this point, queries are divided into two categories.

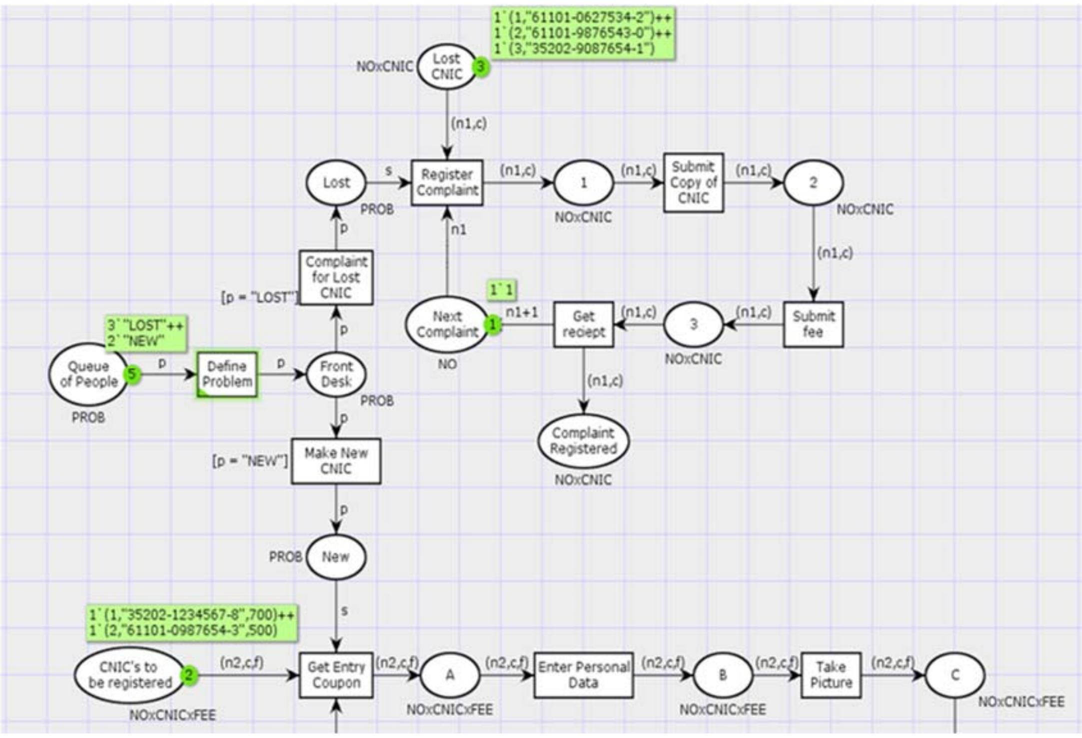

Figure 1. Initial Marking of CPN Model

A. New ID Card (Normal or Urgent Basis)

Our first scenario is to serve people in getting a new ID card either as normal ID card making or urgent ID card need.

Transition defines problem will fire as it has token in its input place queue of people. Token moves to place the front desk. Now, the transition make a new CNIC will be fired and token moves to place new. Transition get entry coupon will be fired if it has token in its both input places new and CNIC's to be registered. When it is fired, token moves to place A. Next transition enter personal data will be fired and token moves to place B. Place B enables transition take a picture. Now token is in place C. Place C enables transition Verify fingerprints. Token moves to place D that enables the transition to submit fee. From submitting fee token moves to place F. Place F enables two transitions named make urgent CNIC and make a normal CNIC. Both transitions have a single output place E. Place E enables transition get receipt. When this transition will be fired, it results in two output places process completed and next in queue. The procedure is shown in Figure 2.

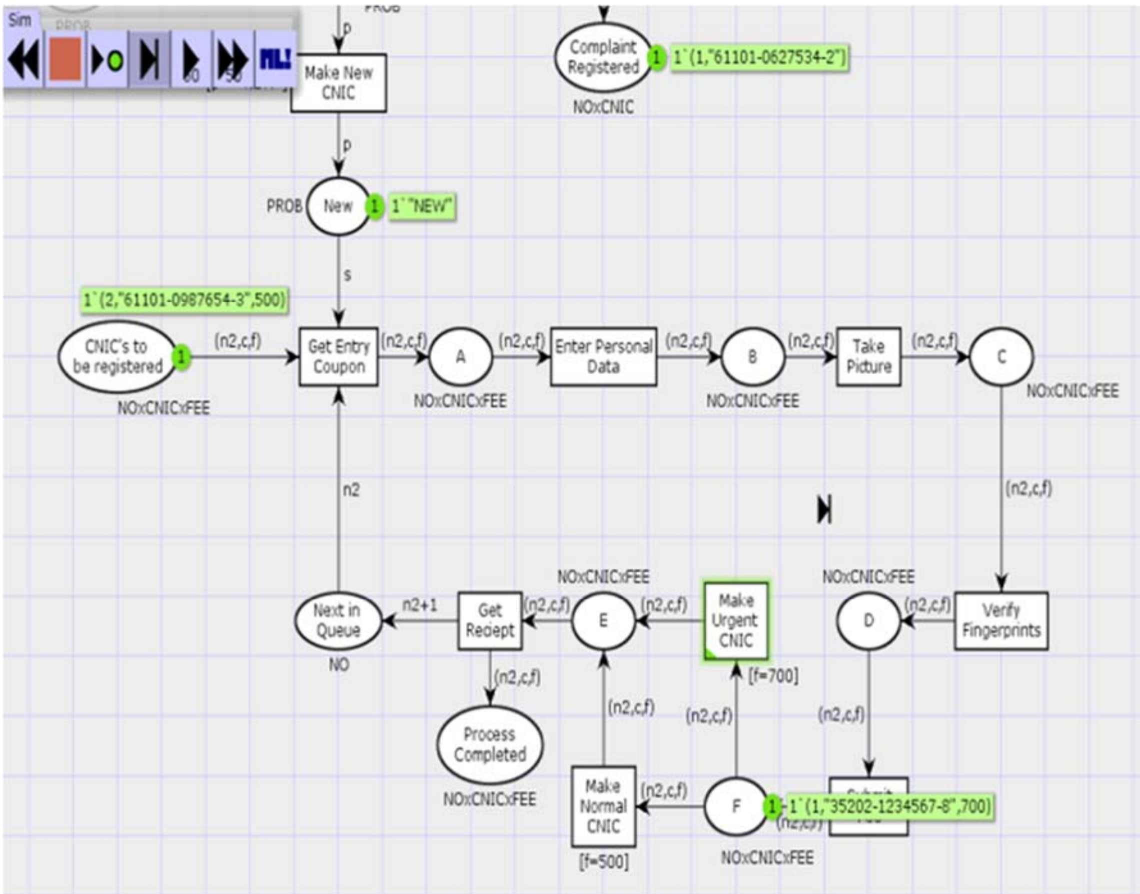

Figure 2. New CNIC Procedure

In the above scenario, two cases are handled which are; making a new ID card and making an urgent ID card. This procedure goes on to serve the next person in the queue. Next person will be served when transition get entry coupon will have tokens in its all input places new, CNIC's to be registered and next in the queue. The procedure for the next entry is shown in Figure 3.

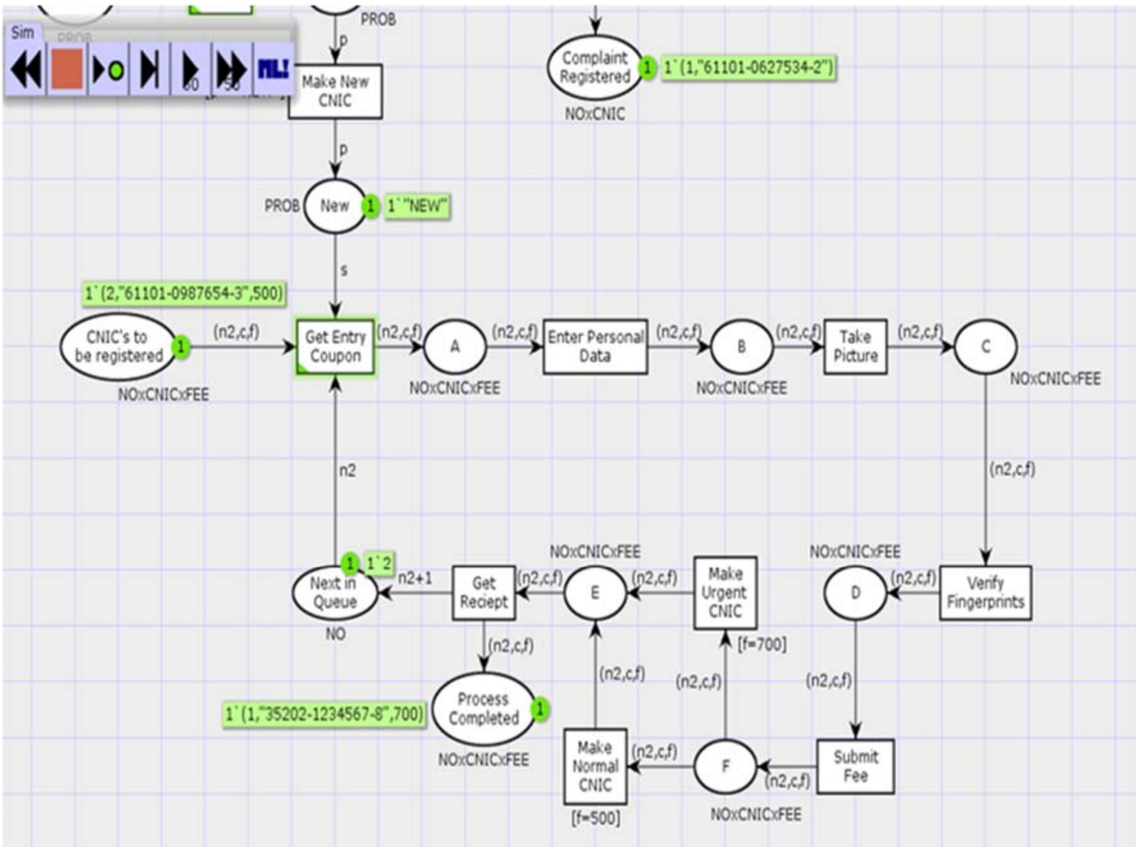

Figure 3. A CNIC successfully registered

B. Lost of NIC

Transition named as a complaint for lost CNIC will be fired and token moves to place Lost. The next transition register complaint will be fired as it has tokens in its both input place LOST and LOST CNIC. Token moves next in place and transition submit copy of CNIC will be fired. Token moves further to place 2 and the next transition submit fee will be fired. Place 3 has token so transition get receipt will be fired next. This transition has two output places as complaint registered and next compliant. This process goes on again to serve the next person in the queue. Next person's complaint will be registered if the transition register complaint will have tokens in its all input places Lost CNIC, Lost, and Next Complaint.

The turn of the next person is shown in Figure 4. This procedure goes on as token flows in the net to serve others in the queue.

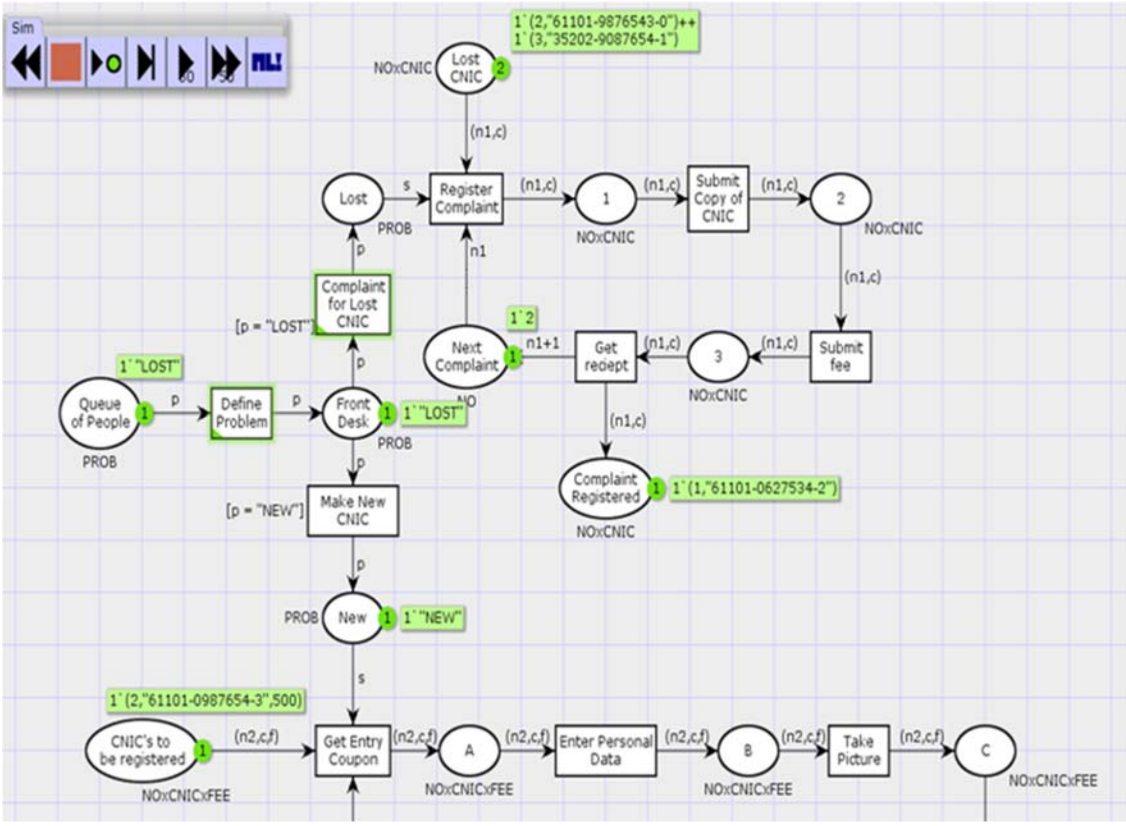

Figure 4. "Complaint for Lost CNIC" is enabled

IV. CPN ML PROGRAMMING LANGUAGE

The language used for modeling a Colored Petri-Net is known as CPN ML Programming Language. There are some color sets and variables that are declared before making a model. The following are the color sets and variables defined in this model.

- Colset NO = int; (for states that have INT type tokens in them, defines the ID of the token).
- Colset CNIC = string; (for states that have STRING type tokens, to store CNIC numbers).
- Colset FEE = int; (to save the fee of applying for a CNIC; urgent or normal).
- Colset PROB = string; (for defining what the query is. Either the CNIC has been lost or a new one is wanted; has one of the two values only; LOST or NEW).
- Colset NOxCNIC = product NO*CNIC (**product** is a keyword used to combine to data types to make a multi-set; to store ID of token and CNIC together for LOST CNIC scenario).
- Colset NOxCNICxFEE = product NO*CNIC*FEE (again a multi-set; to store the fee as well along with ID and CNIC as required by NEW CNIC making procedure).
- Variables **n1** and **n2** belong to NO type.
- Variable **c** belongs to CNIC type.
- Variable **f** belongs to FEE type.
- Variable **p** and **s** belong to PROB type.

All these parameters are shown in Figure 5.

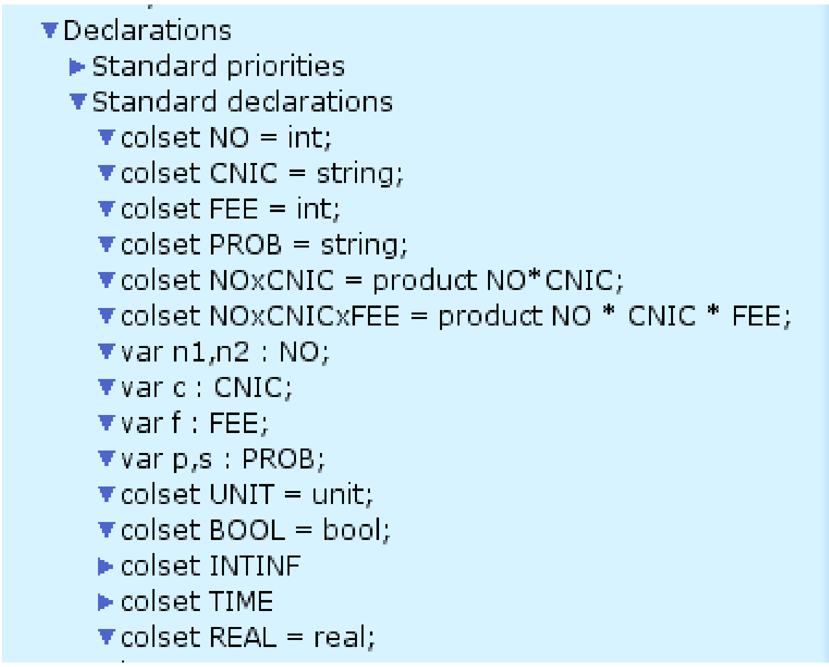

Figure 5. Color Sets and Variables Declarations

A. *Initial Marking*

The initial marking of a CPN model is the tokens that are initially present in one or a few of the place(s). The presence of these token makes one or a few of the transition(s) enabled. Firing such transition(s) starts the flow of the model. In this model, there are five places that have the token in the initially. However, only one of the transitions is enabled initially. Firing this transition enables the rest of the transitions sequentially. The initial marking of this model is given as follows.

- Five tokens (3 “LOST” type and 2 “NEW” type) are present in the place “Queue of People”. Presence of these tokens makes “Define Problem” transition enabled.
- Three tokens are there in “Lost CNIC” state (containing token ID and CNIC of the person).
- Two tokens are present in “New CNIC” state (containing token ID, CNIC, and Fee).
- One token each in “Next Complaint” and “Next in Queue” for Lost and New CNIC, respectively.

As a whole, there twelve tokens in the initial marking and only one enabled transition.

B. *Guards in Transitions*

Guards are the conditions in transitions. Fulfilling these conditions will make the respective transitions enabled. In this model, four transitions have a guard condition. These are:

- A complaint about Lost CNIC (guard: p = “LOST”; the condition will be enabled only if p has the value Lost in it).
- Make New CNIC (guard: p =”NEW”; if the value of p is New, the procedure for New CNIC will be followed).
- Make Urgent CNIC (guard: f = 700; transition is enabled only if fee is 700).
- Make Normal CNIC (guard: f = 500; makes sure fee is 500 to apply for normal CNIC).

These guard conditions control the flow of tokens in the model.

V. STATE SPACE ANALYSIS

State-space identifies all possible reachable states of the E-NIC Issuing system as it is a perfect graph of the system. Representation of all possible edges between two markings is due to the dynamic behavior of the system. Status of such a framework after firing one or more transitions is a marking. The system behavior changes from state to state with respect to time intervals. The detailed state-space analysis report is presented in Table I. There are 1700 nodes and 5256 arcs, and it took about 1 minute to generate a full state space report. Similarly, the SCC graph has four nodes and 1700 arcs and took 0 seconds to generate state-space analysis report.

TABLE I. STATISTICS OF STATE SPACE REPORT

	State Space	Scc Graph
Nodes	1700	1700
Arcs	5256	5256
Secs	1	0
Status	Full	

CPN Models verification is done by defining the behavioral properties of the system. It is impossible to present a complete state-space graph. Figure 6, Figure 7, Figure 8 shows a partial state space graph of the NIC issuing system. It verifies that the system will run in a countless number of occurrences, Furthermore, we have to limit the cycles for termination of the system.

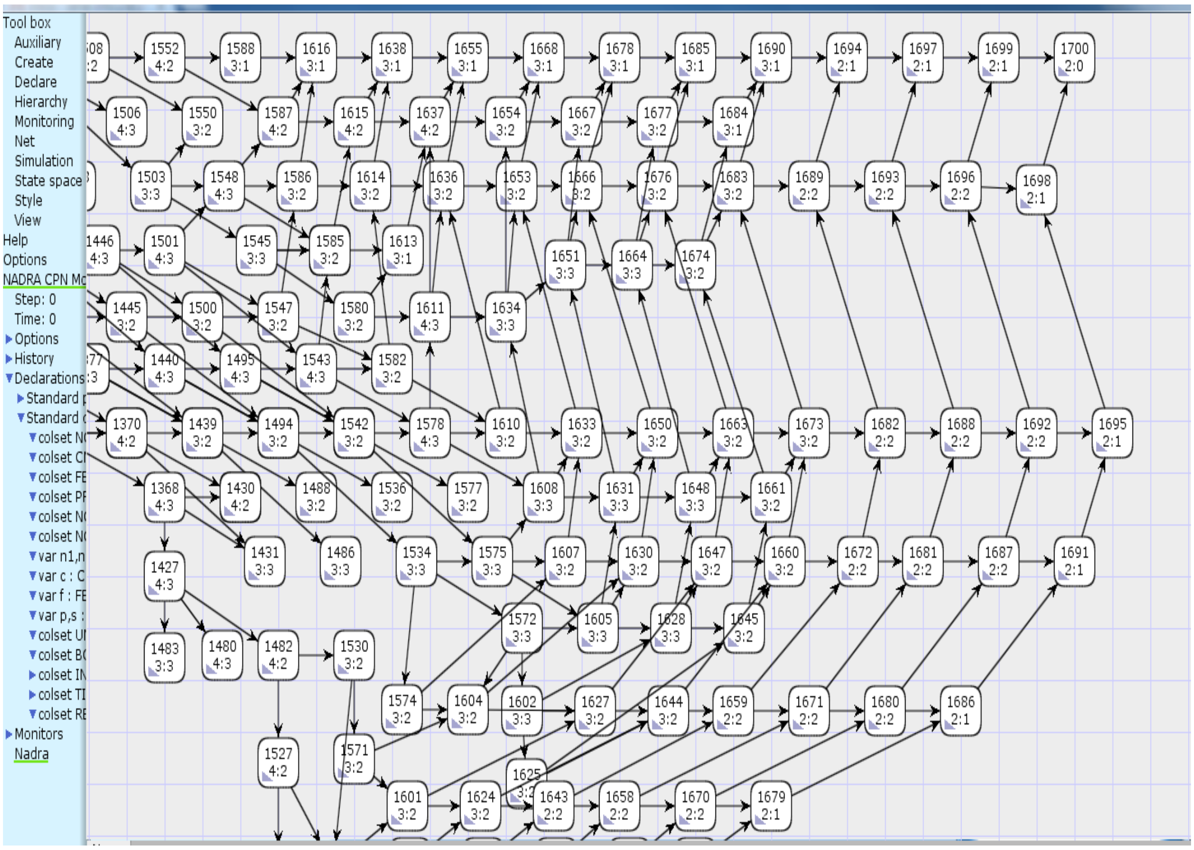

Figure 6. State-Space analysis

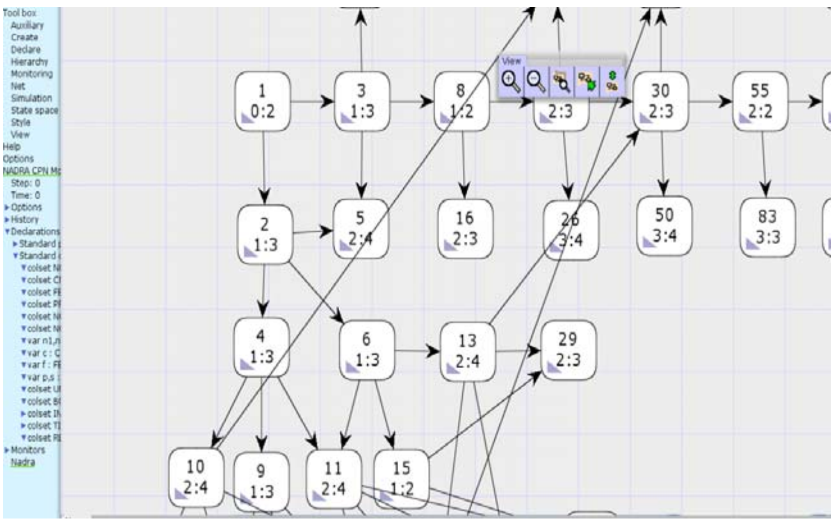

Figure 7. State-Space analysis

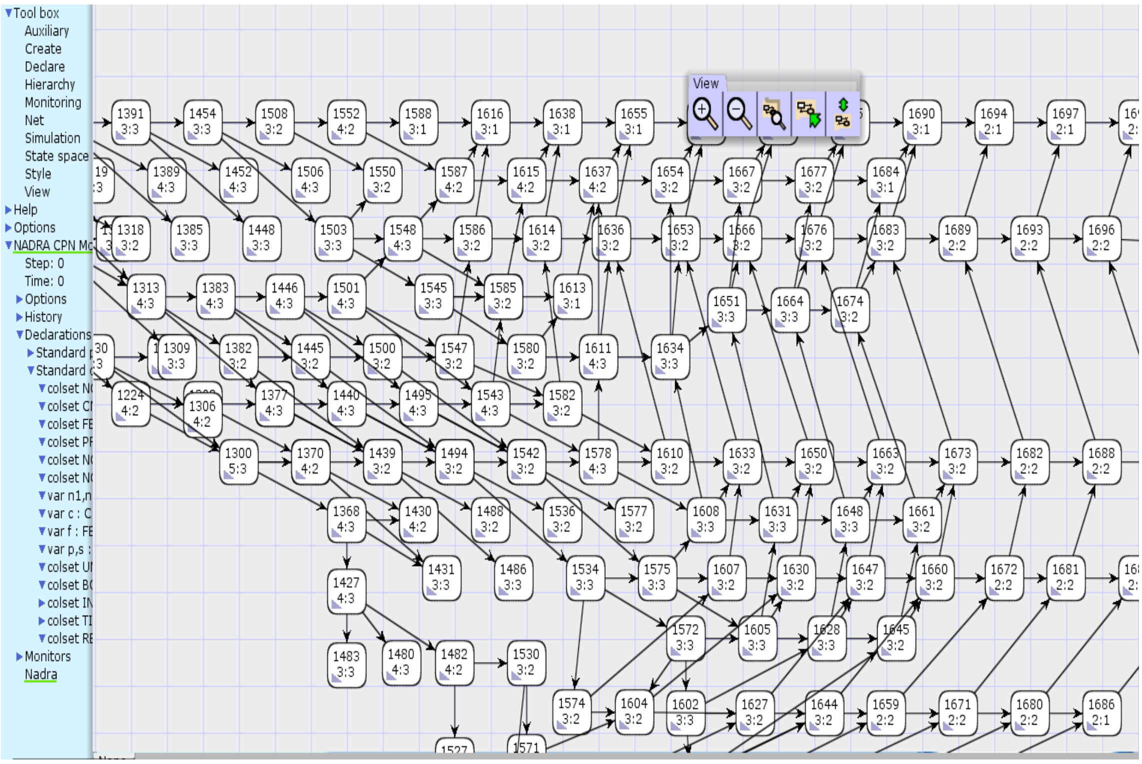

Figure 8. State-Space analysis

VI. CONCLUSION

Modeling dynamic behavior of the NIC issuing system and their analysis provides system verification and validation. It also provides aid to overall system reliability and conformance to specified requirements. For the beneficial purpose as well as fast track procedure of NIC issuing system CPN models are developed. This research focuses on different scenarios of the NIC issuing system. For this purpose, CPN models are developed to check the mechanism as well as the behavior of a system. Also, the main focus of this research is to reduce the error, reduce the time of the procedure, reduce the complexity of the system, and increase the efficiency of the NIC issuing system. This work is done with the help of token flow. CNIC issuing procedure is also a part of a large system. For a better understanding of the NIC issuing system, CPN models are generated and give the idea of how the system works and making it more optimal by adding more services and removing flaws.

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